

BATTERY-OPERABLE PRINTER

This application claims benefits of Japanese Patent Application No. 2000-249915 filed on August 21, 2000, and No. 2001-238323 filed on August 6, 2001, the contents of which are incorporated by this reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

Sub A

The present invention relates to a battery-operable printer, particularly, the invention relates to a printer having a function for checking whether remaining battery capacity has a battery-capacity level sufficient to perform paper transfer operations and print operations. (Hereinbelow, the "paper" refers to paper on which printing is to be performed).

2. Description of the Related Art

In recent years, object images taken by electronic image pickup devices are displayed on a display unit and/or are printed on paper for viewing and preservation.

With technical advances toward compactness and high pixel density of electronic image pickup elements, lightweight and compact electronic image pickup devices have been developed, and are practically used. In advent of such compact and lightweight electronic image pickup devices,

demands are made for compact and lightweight portable printers for printing object images taken by the electronic image pickup devices. In particular, demands are increased for portable printers capable of printing still images of objects taken by the electronic image pickup devices on paper. A conventional example of the portable printers can be operated by two power sources, i.e., one is a commercial power source, and the other is a battery power source. The printer can therefore be driven by the battery power source to perform print operation when the printer is hand-carried.

Sub
B3
However, when the portable printer is operated using the battery to perform printing, problems occur. In the printer, print operation is forced to terminate because of depletion in the battery power. In addition, when printing is resumed after the battery has been replaced, problems such as deviations and the like can occur in print positions before printing terminates and after printing has resumed. To prevent the problems such as print termination and print-positional deviations, techniques have been proposed. Japanese Unexamined Patent Application Publications No. 4-200185 and No. 11-177912 each disclose a printer including a function of checking whether the remaining battery capacity is at a level sufficient to perform printing to produce a desired number of sheets.

Japanese Unexamined Patent Application Publication No.

4-200185 discloses a camera with a built-in printer as a battery-powered portable apparatus having a print function. Before an image captured by the camera is printed, battery-capacity checking is performed. If the battery capacity is sufficient, printing is performed. However, if the battery capacity is not sufficient, a display unit displays a warning, and processing terminates.

AL Japanese Unexamined Patent Application Publication No. 11-177912 discloses a technique similar to the above. According to the technique, a power-source detecting circuit, a warning unit, and a print-information preserving unit are provided in a control circuit that controls a printer. When the print size and the number of sheets are specified, and a print-commencing command is input to the printer, the control circuit drives and controls the power-source detecting circuit to detect the remaining capacity of a power-source battery, and determines whether the printer is capable of performing printing meeting the input requirements for the print size and the number of sheets. If a shortage is foreseen to occur in the remaining capacity of the power-source battery which is required to perform printing meeting the input requirements, the control circuit forcibly disables the print operation and controls the warning unit to display information prompting a user to replace the power-source battery with a new one.

The above-described determination is made based on the amount of power consumption per sheet as a coefficient. The amount of power consumption is obtained by performing experiments. Based on the coefficient, the determination is made whether printing can be performed on the specified number of sheets by using the remaining capacity of the power-source battery.

As described above, in the printer disclosed in Japanese Unexamined Patent Application Publication No. 11-177912, when printing is commenced after the print requirements have been input, the remaining capacity of the power-source battery is detected. Then, the determination is made whether the power-source battery is at a level sufficient to execute printing meeting the input print requirements. If the remaining capacity of the power-source battery is not at a level sufficient to execute printing meeting the input print requirements, the print operation is forced to terminate. Concurrently, the display unit displays information prompting the user to replace the power-source battery with a new one.

The above-described printer is included in an electronic image pickup device. A new object image can be captured during a print operation of an object image captured by the electronic image pickup device. In this case, an electronic image pickup operation is performed by

interrupting the print operation, and after the electronic image pickup operation has been completed, printing for the object image for which the print operation was performed partway is resumed from the position where printing stopped.

In the above-described printer, roll-shaped paper is used, and an inkjet recording method is employed. The printer includes a memory to store image data corresponding to one scanning operation according to the inkjet recording method. During a print operation, an electronic image pickup operation is performed after one scanning operation of image data recorded in the memory. After the electronic image pickup operation has been completed, printing is resumed from image data corresponding to one scanning operation that is performed subsequent to a scanning operation of a printed image. Thereby, the position where printing terminated partway and the position wherefrom printing has resumed is apparent for each print scanning operation, and no positional deviation therefore occurs. This can be achieved with a printer that employs the inkjet printing method.

However, with a printer employing a recording method, such as a dye fusion thermal transfer recording method or a dye diffusion thermal transfer recording method, a driving battery of the printer is depleted in a relatively short period. When printing is thereby terminated in print

operation, a thermal-transferring inked ribbon tends to stop in a state where the ribbon is in contact with paper. When printing is resumed after the battery has been replaced with a new one, driving systems for the inked ribbon and the paper are driven to commence printing from the position where printing terminated partway. For this reason, deviations occur in the print-commencement position, and variations occur in the thermal-transfer temperature. Consequently, differences in density and coloration occur on printed portions where printing terminated partway and printing is resumed.

Sub 43-
According to Japanese Unexamined Patent Application Publication No. 4-200185, battery-capacity checking is performed before a sheet of recording paper is transferred, but nothing is disclosed regarding a method of increasing number of sheets of the paper as many as possible. The method is required when printing is performed on a large number of sheets of the paper.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a battery-operable printer that prevents printing from being terminated partway because of depletion of the battery and that prevents unnecessary paper stagnation which occurs in a paper transfer path when paper transfer terminates partway

because of a shortage in battery power.

A printer of the present invention includes a printing section for performing printing on paper; a paper feed section for transferring paper, which is fed from a paper feed cassette, to the aforementioned printing section; a battery power source; and a remaining-battery-capacity detector for detecting a remaining-battery-capacity level of the aforementioned battery power source. Furthermore, the printer includes a print-operation-commencement specifying section for specifying print-operation commencement, and a control section.

The aforementioned control section performs print-operation control such that the aforementioned remaining-battery-capacity detector is used to detect the remaining battery capacity level immediately before a paper-feed operation is commenced for the first sheet of the paper for a print operation which is commenced corresponding to a print-operation commencement specification received from the aforementioned print-operation-commencement specifying section. On the other hand, the aforementioned control means performs the print-operation control such that when printing is consecutively performed on a plurality of sheets of the paper corresponding to the aforementioned print-operation commencement specification, the aforementioned remaining-battery-capacity detector is used to detect the

remaining battery capacity level immediately before the paper-feed operation is performed for the print operation for each of the plurality of sheets of the paper.

The above and other objects, features, and advantages of the invention will become more clearly understood from description referring to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view showing the overall configuration of a printer according to a first embodiment of the present invention;

Figs. 2A and 2B are perspective views each showing an exterior configuration of the printer of the first embodiment;

Fig. 3 is a flowchart showing an example flow of battery-capacity checking at a power-on time in the printer according to the first embodiment;

Fig. 4 is a flowchart for explaining processing to be performed in printing by the printer of the first embodiment;

Fig. 5 is a flowchart showing an example flow of determination processing for the existence of paper and an inked ribbon in the printer of the first embodiment;

Fig. 6 is a flowchart showing processing to be performed in printing by a printer according to a second

embodiment of the present invention; and

Fig. 7 is a flowchart showing processing to be performed in printing by a printer according to a third embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinbelow, embodiments of the present invention will be described with reference to the accompanying drawings.

First, a first embodiment will be described.

Fig. 1 is a schematic view showing the overall configuration of a printer 1 according to a first embodiment of the present invention. Figs. 2A and 2B are perspective views each showing an exterior configuration of the printer 1 of the first embodiment. Figs. 3 to 5 are flowcharts for explaining operations of the printer 1 according to the first embodiment.

First, referring to Figs. 2A and 2B, a description will be made regarding an exterior configuration of the printer 1 according to the first embodiment of the present invention. The printer 1 of the present embodiment is a portable, compact, and lightweight printer that employs either a dye fusion thermal transfer printing method or a dye diffusion thermal transfer printing method. The printer 1 has an outer housing of which the overall shape is cubic. The outer housing houses a printing section, a paper feed

section, a control section, power source sections, and others. That is, the outer housing houses, for example, driving mechanisms, a driving-and-controlling system, a print-signal control system, and a driving power source system. The driving mechanisms include a paper transferring mechanism, an inked-ribbon transferring mechanism, and a thermal-head driving mechanism. The driving-and-controlling system drives and controls the aforementioned driving mechanism system. The print-signal control system generates image-printing signals according to image data.

A display section 2, an input section 3, and a memory slot 7 are provided on an upper face of the printer 1. The display section 2 is formed of a liquid-crystal display device that indicates operational inputs and operational states of the printer 1. The memory slot 7 receives an external memory device described below. The input section 3 includes a plurality of switches for turning on or off the power sources of the printer 1, for selectively inputting image data to be printed, for inputting specifications of the number of sheets of the paper, and for selectively inputting specifications of various print modes.

An inked-ribbon cassette entry is provided on a right sidewall of the printer 1 as viewed in the figures. In the inked-ribbon cassette entry, an inked-ribbon cassette 4 is inserted. The inked-ribbon cassette 4 contains a feed reel

and a winding reel on which an inked ribbon is wound. As shown in Fig. 2A, the inked-ribbon cassette 4 inserted from the inked-ribbon cassette entry is attached to a predetermined position in the outer housing. The inked-ribbon cassette entry can be closed by a lid 4a.

In the drawings, a paper-cassette insertion opening through which paper cassette 5 is inserted is provided on the front wall of the printer 1. The paper-cassette insertion opening can be closed by a lid 5a when the paper cassette 5 is not inserted (refer to Fig. 2A). As shown in Fig. 2B, the paper cassette 5 is a rectangular-parallelepiped box, and allows a predetermined number of sheets of paper of a predetermined size to be stacked inside. In a state where the paper cassette 5 is inserted in the paper-cassette insertion opening, and printing is performed, sheets of the paper are transferred one by one into the printer 1.

A connector 6 is provided on the left sidewall of the printer 1 as viewed on the figure. The connector 6 connects the printer 1 to an external apparatus, such as an electronic image pickup device or a computer.

A battery (not shown) is attached to a reverse side of the printer 1 to be detachable. The printer 1 has other component members (not shown) including a DC inlet connector and a light emitting diode (LED). The DC inlet connector is

connected to an AC adapter that converts the commercial source power to a driving power for the printer 1. The LED displays a charge state when the aforementioned battery is charged.

Hereinbelow, an interior configuration of the printer 1 will be described with Fig. 1.

The printer 1 is driven by using two driving source powers. One of the source powers is provided through an AC adaptor 11 that converts the commercial source power to a predetermined DC power. The other one of the source powers is provided from a DC battery 12. The AC adaptor 11 and the DC battery 12 are connected to a power controller 13. The power controller 13 comprises a voltage detector 13a and a transformer 13b. The voltage detector 13a detects at least the voltage of the DC battery 12, and the transformer 13b generates the driving power and feeds it to various control systems and signal-processing circuits that are described below. The aforementioned DC battery 12 is of a chargeable type and is charged with power fed from the power controller 13 via a battery-charging circuit 14.

In Fig. 1, a microcomputer 15 performs the overall control for operations of the printer 1. The microcomputer 15 is connected to input keys 16 and a liquid-crystal display panel 18 via a liquid-crystal-panel dedicated microcomputer 17 (which hereinbelow will be referred to as a

"liquid-crystal-panel dedicated CPU 17"). The input keys 16 include various input keys and are disposed in the input section 3. The liquid-crystal display panel 18 is disposed in the display section 2. The liquid-crystal-panel dedicated CPU 17 controls display operations of the liquid-crystal display panel 18 in response to inputs received from the input keys 16 and under the control of the microcomputer 15. In addition, upon being charged and driven by the battery-charging circuit 14, the liquid-crystal-panel dedicated CPU 17 performs display control so that a charge-display light emitting diode 19 (charge-display LED) illuminates. The charge state of the DC battery 12 is detected by the voltage detector 13a. According to control signals sent from the microcomputer 15, control operations are performed. For example, the LED 19 is controlled to turn OFF when charging has been completed. Also, control is performed to disable input operations, which are performed through the input keys 16, in a period in which the charge-display LED 19 illumines.

Via a bus 20, the microcomputer 15 is connected to a flash ROM 21, and a synchronous dynamic random access memory 22 (SDRAM), an IEEE-1284 interface 23, and an external memory interface 25. The flash ROM 21 permits writing of various types of system data controlled by the microcomputer 15, and stores the data. The SDRAM 22 is a buffer memory

that stores image data fed from an electronic image pickup device, an external computer or an external memory. The IEEE-1284 interface 23 receives image data from the electronic image pickup device or the external computer. The external memory interface 25 reads image data from the external memory.

The IEEE-1284 interface 23 is connected to an external CPU connector 24 that connects, for example, the electronic image pickup device or the external computer. The external memory interface 25 is connected to an external memory connector 26. The external CPU connector 24 corresponds to the connector 6 shown in Fig. 2B, and the external memory connector 26 is provided in the memory slot 7 shown in Fig. 2A. The external memory connector 26 or the memory slot 7 is connected to a semiconductor memory called "SmartMedia" (registered trademark), "CompactFlash" (registered trademark), or a "memory stick".

Via an input/output controller 27, the bus 20 is connected to a paper-feed motor driver 28, a thermal-head motor driver 30, an inked-ribbon motor driver 32, and a sensor input circuit 34. The paper-feed motor driver 28 is a driver circuit for driving and controlling a paper-feed motor 29. The paper-feed motor 29 works to draw out paper from the paper cassette 5 and to transfer the paper to a print driving system provided in the printer 1. The

thermal-head motor driver 30 is a driver circuit for driving and controlling a thermal-head motor 31 that drives a thermal head to be pressed and closely engaged with or to be disengaged from a platen roller (not shown) via the inked ribbon and paper. The inked-ribbon motor driver 32 is a driver circuit for driving and controlling an inked-ribbon motor 33 that works to feed and wind the inked ribbon in the inked-ribbon cassette 4 from the feed reel onto the winding reel. Via a sensor interface 35, the sensor input circuit 34 performs input processing for detection signals sent from a plurality of sensors 36 that perform various detections. The plurality of sensors 36 include a sensor for detecting the existence of paper in the paper cassette 5 attached to the printer 1; a sensor for detecting an initial position and an end position of a paper transfer route in the printer 1, in which paper is drawn out of the paper cassette 5 and transferred; a sensor for detecting the commencement position of each color of the inked ribbon; and a sensor for detecting the peripheral temperature of the battery.

In addition, the bus 20 is connected to a thermal head 38 via a thermal-head controller 37. The thermal-head controller 37 performs electrically-conductive control for a plurality of heating elements provided in the thermal head 38 based on image data, thereby causing the heating elements to generate heat. In the thermal head 38, the plurality of

heating elements are disposed perpendicular to the direction along which the paper and the inked ribbon are transferred. According to the electrically-conductive control performed by the thermal-head controller 37 for each of the plurality of heating elements, the plurality of heating elements generate heat. Thereby, coating materials of the three primary colors of yellow (Y), magenta (M), and cyan (C), and overcoating (OP) material are thermally transferred onto the paper.

Moreover, the bus 20 is connected to a JPEG decoder 39. The JPEG decoder 39 is connected to a static random access memory 41 (SRAM) via an image-scaling circuit 40. A JPEG method, which is an image compression scheme, is employed to compress image data retrieved via the IEEE-1284 interface 23 from the external computer connected to the external CPU connector 24. Alternatively, the JPEG method image is used to compress data retrieved via the external memory interface 25 from the external memory connected to the external memory connector 26. The JPEG compression data is retrieved and temporarily stored in the SDRAM 22. The retrieved JPEG compression data is sequentially read therefrom and is decoded by the JPEG decoder 39. The decoded image data is reduced or magnified by the image-scaling circuit 40 based on a scale factor to image data representing an image having a print size, and the image data is then temporarily stored

in a SRAM 41. The image data temporarily stored in the SRAM 41 is read out again. Based on the image data that has been read out again, the thermal-head controller 37 drives and controls the thermal head 38, thereby allowing the image data to be printed.

A heating electric power is supplied to each of the heating elements of the thermal head 38 from the power controller 13 via a head power feed line 42. The thermal head 38 has a temperature-detecting sensor (not shown). Heat temperature data of the thermal head 38, which has been detected by the temperature-detecting sensor, is inputted to the microcomputer 15 through a temperature signal.

Hereinbelow, example operations are described.

For description, an object image is assumed to have been captured using an electronic image pickup device. Compressed image data of the object image is written to an external memory formed of, for example, a semiconductor memory, and is stored therein. The external memory containing the compressed image data is connected to the external memory connector 26 of the printer 1. Then, under the control of the microcomputer 15, the image data is retrieved and stored in the SDRAM 22 via the external memory interface 25.

For the compressed image data retrieved and stored in the SDRAM 22, a specification-inputting operation is

performed. The input keys 16 are operated to perform the specification-inputting operation for print-desired data of the compressed image data, and for the number of sheets of the paper for the specified compressed image data.

After completion of the input operations performed using the input keys 16 for specifying the print-desired data of the compressed image data and the number of sheets of the paper, another specification-inputting operation is performed using the input keys 16 to commence printing. Based on the input, the microcomputer 15 commences control. According to the control, the paper-feed motor 29 is driven via the paper-feed motor driver 28 so that paper is drawn out of the paper cassette 5 and is then transferred to a predetermined paper transfer path. In addition, the microcomputer 15 performs control such that the thermal-head motor 31 is driven via the thermal-head motor driver 30, and the thermal head 38 is thereby closely engaged with the platen roller (not shown) in such a manner that the paper and the inked ribbon are sandwiched therebetween.

The compressed image data specified for printing is read out of the SDRAM 22. Then, the image data is converted by the JPEG decoder 39 and the image-scaling circuit 40 to a print signal. Then, the print signal is temporarily stored in the SRAM 41.

Subsequently, the paper-feed motor 29 and the inked-

ribbon motor 33 are driven to transfer the paper and the inked ribbon in the state where they are sandwiched between the thermal head 38 and the platen roller. Concurrently, according to the compressed image data specified for printing, the thermal-head controller 37 performs supply control for the heating power that is supplied from the power controller 13 through the head power feed line 42. Then, an image according to the image data is printed on the paper.

Subsequently, a detailed description will be made regarding the print operation that is performed by using the DC battery 12.

First, a description will be made regarding processing to be performed when the printer 1 is powered on, referring to Fig. 3.

Fig. 3 is a flowchart showing an example flow of battery-capacity checking at a power-on time in the printer 1.

At step S1 (The word "step" hereinbelow will be omitted), a determination is made whether the printer 1 has been powered on. If the printer 1 has not been powered on, an answer is NO, nothing is executed until the printer 1 is powered on.

If the printer 1 has been powered on, S1 is answered as YES, and remaining battery capacity is detected (S2).

S3
A6

Subsequently to S2, a determination is made whether the detected remaining battery capacity is higher than or equal to a predetermined capacity (predetermined remaining capacity) (S3). If the remaining capacity is lower than the predetermined remaining capacity, S3 is answered as NO, and processing proceeds to S4, a notification of shortage in remaining battery capacity is displayed, and processing then terminates. On the other hand, if S3 is answered as YES, nothing is executed, and processing proceeds to other processing shown in Fig. 4 and the other relevant drawing.

In this way, immediately after a driving-power switch of the printer 1 has been turned ON, the remaining capacity of the DC battery 12 is detected, and a determination is made whether the DC battery 12 has a remaining battery capacity sufficient to perform printing on at least one sheet of paper. Thus, battery-capacity checking can be performed before the specification-inputting operation for printing is performed.

Hereinbelow, a flow of processing in printing will be described. Fig. 4 is a flowchart showing processing to be performed in printing.

~~First, at S11, a user performs an input operation by using the input keys 16 to specify print-desired data of the compressed image data retrieved and stored in the SDRAM 22.~~

At S12, the number of sheets of paper that correspond to the

image data specified through the input keys 16 at S1 is input by using the input keys 16.

Subsequently, at S13, a determination is made to verify the input of the print specification, that is, the input of a print command. If the print specification is determined not to have been input, S13 is answered as NO, and processing returns to S11. If the input of the print specification is verified, an answer is YES, and processing proceeds to S14. Then, determinations are made whether paper is stored in the paper cassette 5, whether the inked-ribbon cassette 4 is set in the printer 1, and whether ink remains sufficient to perform printing on one sheet of the paper (S14). To allow the detection of the remaining ink amount, symbols or the like are indicated at commencement ends of the portions of the three primary colors and the overcoating material in the inked ribbon, and the symbols or the like are detected by an inked-ribbon detecting sensor, which is one of the various sensors 36. By this arrangement, base ends of the three-primary-color portions, and the remaining amount of the inked ribbon can be recognized.

At step S14, if a determination is made that the paper does not exist or that the remaining amount of the inked ribbon is insufficient, step 14 is answered as NO. In this case, the liquid-crystal-panel dedicated CPU 17 is driven, the liquid-crystal display panel 18 displays information

that no paper exists or that the remaining amount of the inked ribbon is insufficient, and the print-commencement operation is terminated (S15). Then, processing terminates.

If S14 is answered as YES, processing proceeds to S16, and the voltage detector 13a detects the currently remaining power capacity of the DC battery 12 (S16). Then, a determination is made whether the currently remaining power capacity of the DC battery 12 is at a level higher than or equal to a predetermined level of remaining capacity (threshold) (S17).

The predetermined level of remaining capacity is represented by a value representing the power required to drive the paper-feed motor 29, the thermal-head motor 31, the inked-ribbon motor 33, and the thermal head 38. Consequently, printing can be performed on at least one sheet of the paper. The predetermined level of remaining capacity is represented by a preliminary set value obtained through calculations, measurements, and the like of driving power required to perform printing on one sheet of the paper. The predetermined level of remaining capacity, which is used in S3 shown in Fig. 3, is set in the same way as above.

At S17, if the currently remaining power capacity of the DC battery 12 is lower than the predetermined value, that is, if transfer and printing for one sheet of the paper which are performed subsequent to the detection of the

remaining capacity level of the DC battery 12 cannot be completed with the currently remaining power capacity, S17 is answered as NO. In this case, the liquid-crystal-panel dedicated CPU 17 is driven and controlled to command the liquid-crystal display panel 18 to display information on shortage in the remaining capacity of the DC battery 12, and the command for commencing print operation is reset (S18). This allows the user of the printer 1 to recognize the shortage in the remaining capacity of the DC battery 12 and to replace or charge the DC battery 12.

At S17, if the currently remaining power capacity of the DC battery 12 is higher than or equal to the predetermined level of remaining capacity, S17 is answered as YES, and processing proceeds to S19.

At S19, the paper-feed motor 29 is driven through the input/output controller 27 and the paper-feed motor driver 28. Thereby, paper stored in the paper cassette 5 is drawn out, and the edge of the paper is set to a print-commencement position.

Subsequently, at S20, the thermal-head motor 31 is controlled and driven by the input/output controller 27 through the thermal-head motor driver 30. Thereby, the thermal head 38 is closely engaged with the platen roller in a state where a Y-color ink portion of the inked ribbon and the paper is sandwiched therebetween. By driving the paper-

feed motor 29 and the inked-ribbon motor 33, the thermal head 38 is heated and driven under the driving control of the thermal-head controller 37, and thermal transfer printing is performed.

Subsequently, at S21, a determination is made whether the printing has been completed. If the printing is determined at S21 not to have been completed, processing returns to S20. If printing is determined to have been completed, S21 is answered as YES. Subsequently, at S22, a determination is made whether printing with all the colors, i.e., all the colors of the three primaries and the overcoating material, has been completed. At S22, if printing only with the Y color is determined to have been completed, and printing with the other colors is determined not to have been completed, processing proceeds to S23. At S23, the thermal-head motor 31 is driven, the thermal head 38 is disengaged from the platen roller, the operation of the inked-ribbon motor 33 is stopped, the paper-feed motor 29 is reversely driven, the paper for which the Y-color printing has been completed is returned to the print-commencement initial position, and printing with the subsequent M color is commenced at S20. In this way, the routine of S20 to S23 is iterated, and printing is performed sequentially with the Y, M, and C colors and the overcoating (OP).

When printing with the colors up to that of the overcoating (OP) is confirmed to have been completed at S22, the printed paper is transferred outside of the printer 1 at S24. Then, at S25, subtraction from a value representing the specified number of sheets of the paper is performed. Subsequently, at S26, a determination is made whether a number of unprinted sheets of the paper are included in the specified number of sheets of the paper. If a number of unprinted sheets of the paper are determined to be included therein, S26 is answered YES, processing returns to S14, and the processing is iterated within the routine starting with the determination for remaining amounts of the inked ribbon and the paper in order to commence printing on the second sheet of the paper. At S26, all the specified number of sheets of the paper is determined to have been printed, the print operation terminates.

As described above, also when printing is consecutively performed on a plurality of sheets of the paper according to the image data and the number of sheets of the paper that were input and specified at S11 and S12, the currently remaining power capacity of the DC battery 12 is detected immediately before a paper-feed operation is performed when printing is commenced on each sheet of the paper. Thereby, a determination is made whether the currently remaining power capacity is at a driving-power level required to

perform printing on one sheet of the paper, and printing is executed only when the remaining capacity of the DC battery 12 is at the required level. When the level of the remaining capacity of the DC battery 12 does not reach the required level, a paper transfer operation is not performed, and a warning is displayed to notify the user of shortage in the battery capacity.

The above enables the prevention of termination that can occur partway during printing because of shortage in remaining battery capacity. In addition, at S26, when a number of unprinted sheets of the paper are included in the number of sheets of the paper, which have been input at S12, processing returns to S14. At S14, when printing is performed on another sheet of the paper, if the remaining battery capacity detected at S16 is determined to be insufficient, the microcomputer 15 performs control such that data representing the unprinted sheets of the paper is stored, and only the stored data is printed after the DC battery 12 has been replaced with new one.

Hereinbelow, referring to Fig. 5, a description will be made regarding a practical example of the processing of determining the existence of the paper and the inked ribbon. Fig. 5 is a flowchart showing an example flow of the determination processing for the existence of the paper and the inked ribbon.

The following will describe a practical example of the determination performed at S14 for the existence of the paper and the inked ribbon, and a practical example of a non-existence case at S15 for the paper or the inked ribbon. At S14a, a determination is made for the existence of the attached paper cassette 5. If the paper cassette 5 is determined at S14a not to have been attached, a warning is displayed at S15a to notify that the paper cassette 5 is not attached. If the paper cassette 5 is determined to have been attached, a determination is made at S14b for the existence of the paper stored in the paper cassette 5.

As a result of the determination at S14b, if the paper is determined not to have been stored in the paper cassette 5, a warning is displayed at S15b to notify that the paper does not exist. If the paper is determined to have been stored in the paper cassette 5, a determination is made at S14c for the existence of the inked-ribbon cassette 4.

In the determination at S14c, if the inked-ribbon cassette 4 is determined not to have been attached, a warning is displayed at S15c to notify that the inked-ribbon cassette 4 does not exist. If the inked-ribbon cassette 4 is determined to have been attached, a determination is made at S14d for the existence of the remaining amount of the inked ribbon in the inked-ribbon cassette 4.

As a result of the determination at S14d, if the

remaining amount of the inked ribbon in the inked-ribbon cassette 4 is determined not to exist, a warning is displayed at S15d to notify that the inked ribbon does not exist. If the remaining amount of the inked ribbon is determined to exist, S16 and the subsequent steps are executed.

As described above in detail, in the printer 1 of the present embodiment, the remaining capacity level of the DC battery 12 is detected immediately before one sheet of the paper is fed for printing. Then, the determination is made whether the detected remaining capacity level of the DC battery 12 is at a level required to perform a print-driving operation for one sheet of the paper. Consequently, only when the DC battery 12 has a power sufficient to perform printing on one sheet of the paper, the print-driving operation is performed. This enables the prevention of termination that can occur partway of printing, and in addition, enables printing to be performed with desired coloration and density on at least one sheet of the paper.

Also when printing is consecutively performed on a plurality of sheets of the paper according to the same image data, the detection for the remaining capacity of the DC battery 12 and the determination for the remaining capacity level thereof are performed immediately before each sheet of the paper is fed for printing. In the course of printing on

the plurality of sheets of the paper, suppose a shortage has occurred in the remaining battery capacity required to perform printing on the subsequent sheets of the paper after printing has been performed on a number of sheets of the paper. In this case, a warning is displayed to notify the user of the shortage in the battery power, and concurrently, a number of unprinted sheets of the paper is displayed on the liquid-crystal display panel 18. Thereby, the user can easily recognize the remaining number of sheets of the paper on which printing is required to be performed.

The electromotive force of a DC battery is variable depending the temperature in the peripheral environment of the DC battery 12. For this reason, the temperature sensor, i.e., the temperature detector, is provided for detecting the temperature in the peripheral environment of the DC battery 12. The remaining capacity level of the DC battery 12 is calculated by using data representing the temperature detected by the temperature sensor and a value representing the detected remaining capacity of the DC battery 12. Then, the calculated remaining capacity level is compared with the predetermined level of the remaining capacity required for the performing the print-driving operation. Thereby, the remaining capacity of the DC battery 12 can be effectively used as a printing-driving power source. In practice, for example, a change is made for the determination criterion

used to determine whether the transfer operation and the printing operation for one sheet of the paper can be completed corresponding to the detection result of the temperature sensor (temperature-measuring means). In other words, the threshold for the battery-capacity checking is changed corresponding to the degree of the temperature in the peripheral environment of the DC battery 12.

In the above-described printer 1 of the present embodiment, also when printing is performed on the plurality of sheets of the paper corresponding to the configuration using the DC battery 12 as the source power, battery-capacity checking is performed before each sheet of the paper is fed for printing, and printing is controlled to securely terminate after the paper has been fed out. As a result of the battery-capacity checking, if a determination is made that printing cannot be completed for data corresponding to another sheet of the paper subsequent to the battery-capacity checking, paper feed is not commenced. Furthermore, in the printer 1, since the battery-capacity checking is performed each time one sheet of the paper is fed for printing, the remaining capacity of the DC battery 12 can be fully used. This increases the number of printable sheets of the paper (the "printable sheets" hereinbelow refers to sheets on which printing can be performed with a battery capacity).

In this way, the printer 1 of the present embodiment controls the print operation such that the level of remaining battery capacity is detected immediately before the paper-feed operation is performed for the first sheet of the paper for the print operation that is commenced corresponding to specifications input for commencing the print operation. Furthermore, the printer 1 controls the print operation such that when printing is consecutively performed on the plurality of sheets of the paper corresponding to specifications for commencing the print operation, the level of remaining battery capacity is also detected immediately before the paper-feed operation is performed for each of the plurality of sheets of the paper for the print operation.

Conventionally, for example, when ten sheets of the paper is specified for the number of sheets of the paper, a determination is made whether printing can be performed on all the ten sheets of the paper. As a result, if printing is determined to be possible, printing is consecutively performed on all the ten sheets of the paper. In this conventional case, while printing may be impossible for all the ten sheets of the paper, also when the remaining battery capacity is at a level sufficient to perform printing on, for example, three sheets of the paper, information the remaining battery capacity is determined to be displayed in

a message saying, for example, "shortage in the battery capacity", and consequently, printing cannot be performed. However, when the above-described printer 1 of the present embodiment is used in the aforementioned situation, also when ten sheets of the paper is specified for printing, printing can be performed on up to three sheets of the paper. When the printer is designed by placing importance on the portability, a small battery having a low capacity needs to be used. However, according to the present embodiment, even with a low-capacitance battery being used, the number of printable sheets of the paper can utmost be increased.

In the above-described printer 1 of the first embodiment, battery-capacity checking is performed immediately before the paper is drawn out of the paper cassette 5 for printing. If a number of sequences are involved between the battery-capacity checking and the paper feed operation, a slight voltage drop can occur therebetween. The battery-capacity checking is iterated in units of the print operation for one sheet of the paper. For example, also when ten sheets of the paper is specified for the number of sheets of the paper in a case where printing on ten sheets of the paper is impossible, the print requirement is not reset, and printing is executed if printing can still be performed on, for example, one sheet of the paper. Furthermore, the printer 1 performs battery-capacity

checking each time printing is performed on one sheet of the paper, thereby enabling battery service life to be prolonged.

The first embodiment employs the method in which the remaining capacity of the DC battery 12 is detected, and the determination is made whether the remaining capacity is at a power level sufficient to perform printing on one sheet of the paper. However, the method may be modified as follows. Based on a value of the power required for performing a print-driving for one sheet of the paper, calculations are performed to obtain the number of sheets of the paper on which printing can be performed. Then, the number of printable sheets of the paper is obtained from the calculation result and the remaining capacity of the DC battery 12, and the number of printable sheets of the paper sheets is displayed on the liquid-crystal display panel 18.

In this way, according to the above-described printer 1, the remaining capacity of the DC battery 12 is detected immediately before each sheet of the paper is fed for printing. When the detected remaining capacity of the DC battery 12 is not at a driving-power level sufficient to perform printing on at least one sheet of the paper, paper feed operation is stopped, and display is performed to notify the user of shortage in the remaining capacity of the DC battery 12. In addition, when printing is performed on a plurality of sheets of the paper, a number of unprinted

sheets of the paper are also displayed. Thereby, printing can be executed immediately before the DC battery 12 is depleted, and printing can be resumed with the first sheet of the unprinted paper.

Hereinbelow, a second embodiment of the present invention will be described.

A printer of the second embodiment has substantially the same configuration as that of the printer of the first embodiment described with reference to Figs. 1 to 5. Description relative to Figs. 1 to 5 will therefore be omitted. Hereinbelow, with reference to Fig. 6, a description will be made regarding the difference of the first embodiment.

Fig. 6 corresponds to Fig. 4 regarding the first embodiment. That is, Fig. 6 is a flowchart showing processing to be performed in printing by the printer according to the second embodiment. Since the flowchart is substantially the same as that shown in Fig. 4, the individual steps of the same processing as those shown in Fig. 4 are represented by the same step numbers.

The difference in this case is the sequence of processes at S14 to S18 shown by the letter A. After the battery-capacity checking has been performed at S17, the determination at S14 is performed for the existence of the paper and the inked ribbon. In the determination at S14 for

the existence of the paper and the inked ribbon, since only checking is performed for outputs of the various sensors, the power consumption therein is low. Also after the battery-capacity checking has been performed, while the remaining capacity of the battery is slightly reduced by the S14, printing can still be performed at a high probability.

Also in the printer configured according to the second embodiment, since substantially the same advantages as those of the first embodiment can be obtained, description of the advantages is also omitted.

Hereinbelow, a third embodiment of the present invention will be described.

A printer of the third embodiment has substantially the same configuration as that of either the printer of the first embodiment described with reference to Figs. 1 to 5 or the printer of the second embodiment described with reference to Figs. 1 to 6. Description relative to Figs. 1 to 6 will therefore be omitted. Hereinbelow, with reference to Fig. 7, a description will be made regarding only portions and matters different from those of the first embodiment and the second embodiment.

Fig. 7 is a flowchart showing processing to be performed in printing by a printer according to a third embodiment of the present invention. In Fig. 7, a modification is added to S17 shown in Fig. 4 regarding the

first embodiment and Fig. 6 regarding the second embodiment. After S16 at which the remaining battery capacity has been detected, determination processing is added to determine whether all the specified number of sheets of the paper can be consecutively printed.

As described above, after the remaining battery capacity has been detected at S16, the determination is made whether all the specified number of sheets of the paper can be consecutively printed (S51). Specifically, the aforementioned determination is made whether the remaining battery capacity detected at S16 is higher than or equal to a predetermined remaining capacity (first threshold). If the remaining battery capacity is higher than or equal to the first threshold, S51 is answered as YES, and processing proceeds either to S19 (in the first embodiment) or to S14 (in the second embodiment). For example, the first threshold is obtained through a calculation that is carried out such that an experimentally obtained power consumption for one printed sheet of paper is used as a coefficient, and based on the coefficient, multiplication is carried out with an input value representing the number of sheets of the paper. If the remaining battery capacity detected at S16 is lower than the predetermined remaining capacity (first threshold), S51 is answered as NO, and processing proceeds to S52. At S52, a determination is made whether the

remaining battery capacity detected at S16 is higher than or equal to a predetermined remaining capacity (second threshold). The second threshold is similar to the remaining capacity level at S17 used in the first and second embodiments to determine whether one sheet of the paper can be printed.

When S52 is answered as NO, that is, when printing cannot be performed even on one sheet of the paper, processing proceeds to S18. On the other hand, when S52 is answered as YES, processing proceeds to S53, and display processing is performed to notify that printing can be performed only on a partial number of sheets of the paper (S53). Then, processing proceeds either to S19 (in the first embodiment) or to S14 (in the second embodiment).

In the above-described operational method, also when all the specified number of sheets of the paper cannot be printed, the battery can be used until printing on the last sheet of the paper is completed. Furthermore, also when printing cannot be performed on all the specified number of sheets of the paper, that is, when the level of remaining battery capacity detected by a battery voltage detector is determined to be at a level sufficient to complete only a partial number of sheets of a plurality of sheets of the paper specified for paper transfer operations and print operations, a notification to that effect is displayed so

that the user can easily understand the operational condition. This improves user-friendly characteristics of the printer. When the remaining capacity is determined to be at the level sufficient to complete only a partial number of sheets of the paper, a display may be presented to notify the user of the number of sheets of the paper that can be printed by using the battery capacity remaining in the stage of S53.

In the printer of the present invention, the remaining capacity of the battery power source is detected immediately before each sheet of the paper is fed for printing, the print-driving operation is performed only when the battery power source has a remaining capacity sufficient to perform printing on at least one sheet of the paper. This averts termination that can occur partway during a print operation because of the depletion in the battery power source. In addition, printing can be performed with predetermined coloration and density. Furthermore, when the battery power source is at a level insufficient to perform the print-driving operation for one sheet of the paper, a warning is displayed on the display section to notify the user of shortage in the battery capacity, and concurrently, the print-driving terminates. This method is advantageous in that the user can easily recognize timing with which batteries are replaced with new ones.

Having described the preferred embodiments of the invention referring to the accompanying drawings, it should be understood that the present invention is not limited to those precise embodiments, and various changes and modification thereof could be made by one skilled in the art without departing from the spirit or scope of the invention as defined in the appended claims.

3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015
1016
1017
1018
1019
1020
1021
1022
1023
1024
1025
1026
1027
1028
1029
1030
1031
1032
1033
1034
1035
1036
1037
1038
1039
1040
1041
1042
1043
1044
1045
1046
1047
1048
1049
1050
1051
1052
1053
1054
1055
1056
1057
1058
1059
1060
1061
1062
1063
1064
1065
1066
1067
1068
1069
1070
1071
1072
1073
1074
1075
1076
1077
1078
1079
1080
1081
1082
1083
1084
1085
1086
1087
1088
1089
1090
1091
1092
1093
1094
1095
1096
1097
1098
1099
1100
1101
1102
1103
1104
1105
1106
1107
1108
1109
1110
1111
1112
1113
1114
1115
1116
1117
1118
1119
1120
1121
1122
1123
1124
1125
1126
1127
1128
1129
1130
1131
1132
1133
1134
1135
1136
1137
1138
1139
1140
1141
1142
1143
1144
1145
1146
1147
1148
1149
1150
1151
1152
1153
1154
1155
1156
1157
1158
1159
1160
1161
1162
1163
1164
1165
1166
1167
1168
1169
1170
1171
1172
1173
1174
1175
1176
1177
1178
1179
1180
1181
1182
1183
1184
1185
1186
1187
1188
1189
1190
1191
1192
1193
1194
1195
1196
1197
1198
1199
1200
1201
1202
1203
1204
1205
1206
1207
1208
1209
1210
1211
1212
1213
1214
1215
1216
1217
1218
1219
1220
1221
1222
1223
1224
1225
1226
1227
1228
1229
1230
1231
1232
1233
1234
1235
1236
1237
1238
1239
1240
1241
1242
1243
1244
1245
1246
1247
1248
1249
1250
1251
1252
1253
1254
1255
1256
1257
1258
1259
1260
1261
1262
1263
1264
1265
1266
1267
1268
1269
1270
1271
1272
1273
1274
1275
1276
1277
1278
1279
1280
1281
1282
1283
1284
1285
1286
1287
1288
1289
1290
1291
1292
1293
1294
1295
1296
1297
1298
1299
1300
1301
1302
1303
1304
1305
1306
1307
1308
1309
1310
1311
1312
1313
1314
1315
1316
1317
1318
1319
1320
1321
1322
1323
1324
1325
1326
1327
1328
1329
1330
1331
1332
1333
1334
1335
1336
1337
1338
1339
1340
1341
1342
1343
1344
1345
1346
1347
1348
1349
1350
1351
1352
1353
1354
1355
1356
1357
1358
1359
1360
1361
1362
1363
1364
1365
1366
1367
1368
1369
1370
1371
1372
1373
1374
1375
1376
1377
1378
1379
1380
1381
1382
1383
1384
1385
1386
1387
1388
1389
1390
1391
1392
1393
1394
1395
1396
1397
1398
1399
1400
1401
1402
1403
1404
1405
1406
1407
1408
1409
1410
1411
1412
1413
1414
1415
1416
1417
1418
1419
1420
1421
1422
1423
1424
1425
1426
1427
1428
1429
1430
1431
1432
1433
1434
1435
1436
1437
1438
1439
1440
1441
1442
1443
1444
1445
1446
1447
1448
1449
1450
1451
1452
1453
1454
1455
1456
1457
1458
1459
1460
1461
1462
1463
1464
1465
1466
1467
1468
1469
1470
1471
1472
1473
1474
1475
1476
1477
1478
1479
1480
1481
1482
1483
1484
1485
1486
1487
1488
1489
1490
1491
1492
1493
1494
1495
1496
1497
1498
1499
1500
1501
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
1512
1513
1514
1515
1516
1517
1518
1519
1520
1521
1522
1523
1524
1525
1526
1527
1528
1529
1530
1531
1532
1533
1534
1535
1536
1537
1538
1539
1540
1541
1542
1543
1544
1545
1546
1547
1548
1549
1550
1551
1552
1553
1554
1555
1556
1557
1558
1559
1560
1561
1562
1563
1564
1565
1566
1567
1568
1569
1570
1571
1572
1573
1574
1575
1576
1577
1578
1579
1580
1581
1582
1583
1584
1585
1586
1587
1588
1589
1590
1591
1592
1593
1594
1595
1596
1597
1598
1599
1600
1601
1602
1603
1604
1605
1606
1607
1608
1609
1610
1611
1612
1613
1614
1615
1616
1617
1618
1619
1620
1621
1622
1623
1624
1625
1626
1627
1628
1629
1630
1631
1632
1633
1634
1635
1636
1637
1638
1639
1640
1641
1642
1643
1644
1645
1646
1647
1648
1649
1650
1651
1652
1653
1654
1655
1656
1657
1658
1659
1660
1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
1681
1682
1683
1684
1685
1686
1687
1688
1689
1690
1691
1692
1693
1694
1695
1696
1697
1698
1699
1700
1701
1702
1703
1704
1705
1706
1707
1708
1709
1710
1711
1712
1713
1714
1715
1716
1717
1718
1719
1720
1721
1722
1723
1724
1725
1726
1727
1728
1729
1730
1731
1732
1733
1734
1735
1736
1737
1738
1739
1740
1741
1742
1743
1744
1745
1746
1747
1748
1749
1750
1751
1752
1753
1754
1755
1756
1757
1758
1759
1760
1761
1762
1763
1764
1765
1766
1767
1768
1769
1770
1771
1772
1773
1774
1775
1776
1777
1778
1779
1780
1781
1782
1783
1784
1785
1786
1787
1788
1789
1790
1791
1792
1793
1794
1795
1796
1797
1798
1799
1800
1801
1802
1803
1804
1805
1806
1807
1808
1809
1810
1811
1812
1813
1814
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
1826
1827
1828
1829
1830
1831
1832
1833
1834
1835
1836
1837
1838
1839
1840
1841
1842
1843
1844
1845
1846
1847
1848
1849
1850
1851
1852
1853
1854
1855
1856
1857
1858
1859
1860
1861
1862
1863
1864
1865
1866
1867
1868
1869
1870
1871
1872
1873
1874
1875
1876
1877
1878
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063
2064
2065
2066
2067
2068
2069
2070
2071
2072
2073
2074
2075
2076
2077
2078
2079
2080
2081
2082
2083
2084
2085
2086
2087
2088
2089
2090
2091
2092
2093
2094
2095
2096
2097
2098
2099
2100
2101
2102
2103
2104
2105
2106
2107
2108
2109
2110
2111
2112
2113
2114
2115
2116
2117
2118
2119
2120
2121
2122
2123
2124
2125
2126
2127
2128
2129
2130
2131
2132
2133
2134
2135
2136
2137
2138
2139
2140
2141
2142
2143
2144
2145
2146
2147
2148
2149
2150
2151
2152
2153
2154
2155
2156
2157
2158
2159
2160
2161
2162
2163
2164
2165
2166
2167
2168
2169
2170
2171
2172
2173
2174
2175
2176
2177
2178
2179
2180
2181
2182
2183
2184
2185
2186
2187
2188
2189
2190
2191
2192
2193
2194
2195
2196
2197
2198
2199
2200
2201
2202
2203
2204
2205
2206
2207
2208
2209
2210
2211
2212
2213
2214
2215
2216
2217
2218
2219
2220
2221
2222
2223